WEP Warwick Evans Publishing

Transactions on Economics, Business and Management Research
ISSN: 2960-1789, eISSN: 2960-2254 | Volume 7
EDMI 2024

Can Digital Transformation Improve ESG Performance?

-- Empirical Evidence from A-share Listed Companies

Lingyun Du *

School of Business, Chengdu University of Technology, Chengdu, China

* Corresponding author Email: lingyundu80@163.com

Abstract. Taking the A-share listed companies on Shanghai and Shenzhen stock exchanges from 2009 to 2020 as samples. This paper uses Python to construct an index of digital transformation by analyzing text data from enterprises' annual reports and examines its impact on enterprise ESG performance and impact channels. The empirical results show that digital transformation can significantly improve the ESG performance of the enterprise. This finding is still valid after a series of robustness and endogeneity tests. Mechanistic tests show that digital transformation contributes to ESG performance by enhancing the capability for green innovation and improving the quality of information disclosure. Heterogeneity analysis shows that the effectiveness of digital transformation is affected by the nature of property rights and the management's green perception. This research expands the application of enterprise digital transformation and provides solutions for enterprises to achieve sustainable development.

Keywords: Digital Transformation; ESG; Sustainable Development; Green Innovation.

1. Introduction

Sustainable development has emerged as a key area of focus for global economic and social progress in recent years, and the adoption of green management practices is essential for enterprises to achieve success [1]. At the same time, enterprises are now crucial drivers of high-quality development and the green transition [2]. ESG, which focuses on enterprises from the three dimensions of ecological environmental protection, social responsibility fulfillment, and governance improvement, is a comprehensive evaluation system to measure the prospects of corporate sustainable development, and its concept and related practices have also attracted wide attention worldwide. The effects of carrying out ESG operations, such as lowering financing costs [3], raising enterprise value [4], and boosting credit ratings [5], have been the primary focus of previous research. On the other hand, research on the variables affecting ESG is scarce. Improving corporate ESG has emerged as a key concern in light of China's efforts to meet the "dual-carbon" target. This is essential because achieving sustainable development for businesses depends heavily on it.

China's digital transformation is being driven, at the same time, by the acceleration of the global scientific and technological revolution and industrial change. The Report on the Development of China's Digital Economy (2023) reveals that in 2022, the scale of China's digital economy reached 50.2 trillion yuan, accounting for 41.5% of GDP, and the digital economy has grown to be a significant force in China's economic transformation [6], boosting the country's economic development model from traditional investment-driven to innovation-driven with the digital economy at its core [7]. As a vital driver of high-quality economic development, digital inputs provide fresh momentum for the green transformation of enterprises and have a profound impact on the transformation and modernization of the whole social economy [8]. A number of policy documents, including the "14th Five-Year Plan for the Development of Digital Economy" released by the Chinese government, outline the objectives of hastening the digital transformation and upgrading of businesses, encouraging them to improve their digital thinking, and supporting industry leaders in their role as role models in opening up digital resources to facilitate widespread digital transformation that includes SMEs and traditional businesses. Existing literature shows that through digital transformation, enterprises can significantly reduce customer search costs and switching costs,

improve bargaining power [9], enhance innovation capabilities, improve total factor productivity [10], optimize production processes and improve operational efficiency [11]. However, these studies pay more attention to the economic consequences brought by digitalization, while there is a dearth of research on how digital transformation affects ESG and its action channels.

This paper builds an index to quantify the level of corporate digital transformation by analyzing the text data related to corporate digital transformation in annual reports, using Chinese A-share listed companies in Shanghai and Shenzhen from 2009 to 2020 as the research sample. This allows for a quantitative investigation of the internal relationship between digital transformation and ESG. Compared with the existing literature, the main contributions of this paper are reflected in three aspects. First, this study provides a new perspective for the field of sustainable development and enriches the existing literature on the antecedents of ESG, advancing research on the influencing factors of enterprise ESG performance. Second, from the perspectives of corporate ownership and management's green cognition, this paper explores the impact of digital transformation on enterprises' performance of ESG in different environments, which enriches and expands the research on enterprises' digital transformation and ESG performance, and helps enterprises better explore and implement digital transformation strategies. Finally, this paper delves deeper into the analysis of the impact of digital transformation on ESG performance. It highlights the critical role that Chinese enterprises play in advancing sustainable development within the framework of high-quality economic development by means of green technology innovation and transparent disclosure of high-quality information. This not only helps enterprises play a key role in promoting the "dual carbon" goal, but also provides a theoretical basis for enterprises to enhance comprehensive strength and build long-term competitiveness.

2. Theoretical Analysis and Research Hypothesis

The conventional corporate objectives of profit and value maximization have given way to comprehensive objectives that include environmental, social, and governance (ESG) components in the present business environment. With the increasing awareness of governments, investors and consumers on whether enterprises actively fulfill their social responsibilities, stakeholders pay more attention to environmental sustainability information disclosure [12], and improving enterprises' ESG performance has become a new focus of academic research.

Before digital transformation, the common challenge faced by enterprises is that the costs of ESG activities often exceed their direct economic benefits. On the one hand, the implementation of these activities usually requires significant initial investment, and many enterprises are under pressure of short-term performance, but the positive benefits brought by ESG activities are often long-term [13], while management appraisal is generally related to short-term performance of enterprises. This contradiction between short-term benefits and long-term benefits may make it difficult for enterprises to undertake initial ESG investment [14]. On the other hand, it is challenging to define and quantify the benefits of ESG activities [15], and enterprises need to invest resources to track, measure and report the effectiveness of ESG activities.

With the development of digital economy, digital transformation has emerged as a crucial factor to promote the growth of enterprises. Enterprise digital transformation introduces digital technology into the existing enterprise management system, which fundamentally reshapes the enterprise information structure, management mode, operation mechanism and production process [16]. The newest wave of digital technology gives enterprises a fresh avenue for growth and technical assistance in carrying out their environmental, social, and governance obligations. Its popularization and maturity have brought profound changes to enterprises in business model [17], organizational structure [18], business process [19], management mode [20], information disclosure [21] and other aspects. Based on the above analysis, this paper puts forward the following hypothesis.

Hypothesis 1. Enterprises' digital transformation can improve their ESG performance.

The performance of social responsibility has received extraordinary attention from all facets of society in recent years. To satisfy the demands of numerous investors, enterprises proactively carry out ESG ratings and allocate more funds towards green technology innovation endeavors [22]. Green technology innovation is now the primary engine for achieving high-quality development and will be the cornerstone of enterprises' green transformation and upgrading [23], providing technical support for the improvement of enterprises' environmental performance. As the micro subjects of transformation and upgrading, enterprises are carrying out green innovation and contributing to the simultaneous improvement of economic and environmental quality [24]. On the one hand, in the process of green innovation, enterprises produce more energy-saving products and consume fewer resources, which helps to reduce environmental pollution and over-exploitation of resources [25]. On the other hand, enterprises can better control pollution, cut waste emissions, and save energy by using sophisticated environmental monitoring and management technologies to gather and analyze environmental data, identify environmental risks, and pinpoint areas for improvement. Such progress in management efficiency and transparency further enhances investors' and consumers' trust and recognition of corporate environmental responsibility. Chinese enterprises' green innovation is significantly fueled by institutional investors [26]. Institutional investors with a longer investment period have a clear preference for green investment [27]. In terms of the supply side of green innovation, a better corporate capacity for green innovation will draw in more institutional investors, which will feed the positive feedback loop by providing more funding for corporate green innovation. At the same time, on the demand side, enterprises are more proactive in carrying out pertinent obligations, encouraging the development of positive relationships between enterprises and green investors, and forcing enterprises to grow in a more environmentally and sustainably friendly direction in order to satisfy the interest demands of green investors for environmental protection and social responsibility. Based on the above analysis, this paper puts forward the following hypotheses.

Hypothesis 2. Industrial digital transformation can improve the ESG performance of enterprises by improving their green innovation capabilities.

The internal digital transformation of enterprises has significantly improved the ability of information collection, processing and output, enabling enterprises to generate standardized and structured data, and are more inclined to actively and timely disclose more accurate and transparent information to the market, providing stakeholders with more comprehensive information about the operation status of enterprises. Thus, it improves the quality and efficiency of information disclosure [28]. By improving the quality of information disclosure, digital transformation reduces the information asymmetry between enterprises and external stakeholders [29], enabling stakeholders to supervise enterprises' ESG practices more effectively, thus promoting enterprises' performance in environmental, social and governance aspects. In addition, enterprises that disclose high-quality accounting information are better able to identify the gaps in their ESG performance and fill them, improving their ability to fulfill market and policy demands [4].In addition, high-quality information disclosure is beneficial for enterprises to show their achievements in fulfilling ESG responsibilities to stakeholders [30]. This helps stakeholders have a better understanding of the company's performance [31], boosting the perception of the company brand, drawing in investors and customers that value sustainable development, thus gaining competitive edge in the marketplace and further promoting the improvement of ESG performance. Based on the above analysis, this paper proposes the following hypothesis.

Hypothesis 3. Enterprise digital transformation can improve the performance of ESG by improving the quality of information disclosure.

3. Research Design

3.1. Data Source

This paper selects A-share listed companies in Shanghai and Shenzhen from 2009 to 2020 as the research sample. In order to avoid other interference factors, this paper conducts the following processing on the samples: (1) excluding samples from the financial and insurance industry; (2) excluding ST and *ST samples; (3) excluding samples of companies with less than 10 years of data to reflect the long-term impact of enterprise digital transformation on ESG performance; (4) excluding samples with missing key variables. Finally, 18660 annual observations of 1636 listed companies were obtained. Considering the influence of extreme values on the significance of the test results, the continuous variables were processed by 1%Winsor. The enterprise digital transformation data used in this paper are obtained by crawling the annual report text of CNINFO with Python, and using jieba database to count the keyword frequency of digital transformation. The ESG performance data of Huazheng are sourced from the Wind database, and the financial data and corporate governance data of other listed companies are sourced from CSMAR.

3.2. Variable Selection and Indicator Description

(1) Explained variable

The explained variable is level of ESG. In view of the completeness and availability of data, this paper refers to Fang and Hu [32] and employs Huazheng ESG rating data, which has been rated quarterly since 2009, covering all A-share listed companies. It classifies the ESG performance of publicly traded entities into nine tiers: C, CC, CCC, B, BB, BBB, A, AA, and AAA. These tiers are assigned a value of 1 to 9 from low to high. The average of the four quarterly indicators of each year is taken as the index of the current year.

(2) Explanatory variable

The explanatory variable is the level of enterprise digital transformation. This paper refers to the existing research method of digital transformation [33], and employs Python to count the keyword frequency of digital transformation to reflect the degree of enterprise digital transformation. The specific operation process is as follows: (a) construct the index system of digital transformation from five dimensions to form the lexicon of enterprise digital transformation. The first four dimensions of the map are based on the level of "underlying technology application", which are artificial intelligence technology, big data technology, cloud computing technology and blockchain technology. The last dimension is based on the level of "technology practice application", which is the application of digital technology. There are 76 keywords in the five dimensions, which can reflect the degree of enterprise digital transformation in a more comprehensive way. (b) using Python web crawler technology to download the annual report text of research samples from CNINFO; (c) using pdfplumber library in Python to convert pdf text into txt text for word frequency statistics; (d) using the word segmentation function of jieba library in Python to extract the word frequency of digital transformation keywords from the annual report text file (txt), and the word frequency of the sample in the year is summed up. Additionally, because this kind of data is "right skewed", logarithmic processing is used to depict the degree of digital transformation during the year.

(3) Mediating variables: green innovation capability and quality of information disclosure

Considering that patent application is more timely than authorization, this paper refers to the method of Liu et al. [34], and uses the natural logarithm of the total number of green invention patents and utility model patents applied by enterprises in that year plus one to measure the green innovation capability (GI) of enterprises. The quality of information disclosure refers to the research of Yi et al. [35], and adopts the rating results of information disclosure quality of listed companies in Shenzhen Stock Exchange as its measurement index. The rating results are A, B, C and D from high to low, with the values of 4, 3, 2 and 1 respectively.

(4) Control variable

Referring to existing literature [36,33,37], this paper selects a series of control variables that affect the ESG performance of enterprises. Including enterprise size, enterprise age, proportion of independent directors, dual, ownership concentration, board size, operating income growth rate, asset-liability ratio, cash flow, return on assets. See Table 1 for a description of the main variables.

Table 1. Description of main variables1

Variable type	Variable name	Variable symbol	Variable description
Explained variable	Level of ESG	ESG	Assigned value based on annual rating by Huazheng ESG
Explanatory variables	Level of digital transformation	Dgt	ln (number of digital transformation keywords in the annual report + 1)
Mediating variable	Green innovation capability	GI	ln (number of green patent applications + 1)
	Quality of information disclosure	Disclosure	Assigned value based on annual listed companies information disclosure quality rating by Shenzhen Stock Exchange
Control variables	Enterprise size	Size	Natural logarithm of annual total assets
	Years established	Age	ln (current year - year of establishment + 1)
	Proportion of independent directors	Indep	Number of independent directors/number of directors
	Dual Role of the Board Chairman	Dual	The combination of chairman and general manager is 1, and 0 otherwise
	Ownership concentration	TOP1	Number of shares held by the largest shareholder/total share capital at year-end
	Size of Board of Directors	Board	Total number of board members
	Growth rate of operating income	Growth	(Operating income for the current period - operating income for the previous period)/operating income for the previous period
	Asset-liability ratio	Lev	End-of-year total liabilities / End-of-year total assets
	Cash flow	Cash	Net cash flow from operating activities/total assets
	Return on assets	ROA	(Total profit + finance expenses)/average total assets

3.3. Research Model

In order to study the impact of the degree of enterprise digital transformation on ESG performance, this paper constructs the following model:

$$ESG_{i,t} = \beta_0 + \beta_1 Dgt_{i,t} + \beta_2 Control_{i,t} + \sum Year + \sum Ind + \varepsilon_{i,t}$$

Where $ESG_{i,t}$ is the level of ESG, $Dgt_{i,t}$ is the Level of digital transformation, and $Control_{i,t}$ are control variables, $\varepsilon_{i,t}$ is a random perturbation term. At the same time, this paper also controls the fixed effects of year (Year) and industry (Ind).

4. Empirical Results

4.1. Descriptive Statistics

The results of descriptive statistics are shown in Table 2. The results show that the average ESG level of enterprises during the sample period is 4.1860, and the standard deviation is 1.0530, indicating that the average ESG level of A-share listed companies aged 10 years or above in China is between B and BB, and there is still some room for development. The mean of digital transformation level is 2.5292, the standard deviation is 1.3697, and the median is 2.4849, reflecting the A-share listed companies aged 10 years or above in China have obvious signs of digital transformation, and the overall level is in the medium level.

Table 2. Descriptive statistics2

Variables	Mean	Std. Dev.	Min	p50	Max
ESG	4.185959	1.052986	1	4	8
Dgt	2.529207	1.36972	0	2.484907	7.311886
Size	22.33918	1.31016	20.06863	22.15181	26.39511
Age	16.78891	5.894728	0	17	42
Indep	0.372765	0.0565528	0	0.3333	0.8
Dual	0.2293676	0.4204374	0	0	1
TOP1	0.3465925	0.1508337	0.028657	0.326057	0.899858
Board	8.797856	1.758589	0	9	18
Growth	0.157006	0.3325326	0.497636	0.1065945	1.865632
Lev	0.4258125	0.2002915	0.0479	0.42655	0.8431
Cash	0.0493299	0.0666784	0.1414097	0.0473515	0.2378674
ROA	0.0451351	0.05222	0.150138	0.039378	0.21225

4.2. Benchmark Regression

Table 3. Benchmark regression3

Variables	(1) ESG	(2) ESG
Dgt	0.101 * * *	0.0540 * * *
	(0.0139)	(0.0120)
Controls	No	Yes
Year	Yes	Yes
Industry	Yes	Yes
Observations	18660	18660
R-squared	0.504	0.520

Note: The numbers in parentheses are t-values, and ***, ** and * indicate significance at the levels of 1%, 5% and 10%, respectively. The following table is the same.

The benchmark regression results of digital transformation on the enterprise ESG level are shown in Table 3. In Column (1), no control variables are added, and only year and industry fixed effects are controlled. The results show that the regression coefficient of digital transformation on ESG level is

0.101, which is significantly positive at the level of 1%, indicating that there is a significant positive correlation between enterprise digital transformation and ESG performance. In Column (2), a series of control variables are further added, covering the basic information, governance level, profitability and other aspects of the company, and its regression coefficient is 0.0540, which is also significant at the level of 1%, indicating that every 1% increase in the level of enterprise digital transformation will increase the ESG level by 0.054%. In conclusion, the digital transformation of enterprises can effectively improve their ESG performance.

4.3. Robustness Test

4.3.1. Replace Explanatory Variable

This study replaces the explanatory variables since the results will be impacted by the explanatory factors' measurement technique. Due to the differences in the length of the MD&A section of the company's annual report, this paper refers to the practice of Yuan et al. [38]. After extracting the frequency of each keyword in the annual report of each listed company, the sum of the frequency of words related to enterprise digitalization divided by the length of MD&A paragraphs in the annual report is used to measure the degree of enterprise digitalization (Digital), and put it into the model for regression analysis. The results are shown in Table 4, the regression coefficient of Digital is 0.0433, which is still significantly positive at the level of 5%.

4.3.2. Time-lag Effect

This paper regresses digital transformation with one lag (Digital_1) in order to account for the possibility that there is still a lag effect in the influence of corporate digital transformation on ESG level. The test findings are displayed in Column (2) of Table 4. The regression coefficient of Digital_1 is 0.0362, which is still significantly positive at the level of 1%.

Table 4. Robustness test4

Variables	(1) Replace explanatory variable	(2) Lag one period
	ESG	ESG
Digital	0.0433 * *	
	(0.0208)	
Digital_1		0.0362 * * *
		(0.0116)
Controls	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
Observations	18660	18660
R-squared	0.207	0.548

4.3.3. Rule out Strategic Behavior Explanations

This paper constructs an index of the degree of digitalization of enterprises based on the information disclosed in the annual report. For example, the degree of digital transformation disclosed in the annual report may be higher than the degree of digital transformation actually promoted. In order to eliminate potential interpretation bias, this paper conducts the following processing: (1) Since Growth Enterprise Market (GEM) listed companies are usually more closely related to digitalization, there may be exaggerations in the disclosure of digital transformation, so the sample of GEM listed companies is excluded and the test is re-conducted. (2) Since some enterprises did not carry out digital transformation in some years during the sample period, the regression results may be affected and interfered, so the samples with digital transformation degree of 0 are excluded. (3) Only samples of

listed companies that are rated as excellent or good in the information disclosure evaluation of the stock exchange are retained, because the probability of strategic information disclosure behavior of these companies is relatively low.

The test results are shown in Table 5. The data from columns (1) to (3) show that the coefficient of enterprise digital transformation (Dgt) remains significantly positive at the level of 1%. This shows that the basic conclusion of this paper is still stable despite the consideration of enterprises' possible strategic information disclosure behaviors, and so there is a positive correlation between the degree of digital transformation and ESG performance, which is not significantly affected by enterprises' strategic information disclosure behaviors.

Table 5. Robustness test: excluding the explanation of strategic behavior5

Variables	(1) Excluding GEM listed companies	(2) Excluding the samples with the degree of digital transformation of 0	(3) Keep only samples with an excellent or good level of disclosure
	ESG	ESG	ESG
Dgt	0.0563 * * *	0.0520 * * *	0.0497 * * *
	(0.0131)	(0.0138)	(0.0138)
Controls	Yes	Yes	Yes
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Observations	15813	17566	12866
R-squared	0.214	0.209	0.211

4.4. Moderating Effect Test

4.4.1. Property Right Nature

State-owned companies (SOEs), the backbone of the national economy, are tasked with fundamental responsibilities like social stability, national strategy, and the economy and livelihood of the populace. Therefore, fulfilling social obligations and enhancing ESG performance are state-owned enterprises' inherent missions and crucial duties. In contrast to private enterprises, SOEs are often subject to more stringent oversight and may encounter elevated social and external demands. In addition to actively supporting national strategies like poverty alleviation and rural revitalization, they also devote themselves to the national goal of carbon peak and carbon neutrality, engage in social welfare initiatives, standardize internal control and risk management, and continuously improve corporate governance structure. So they could enjoy a first-mover advantage and play a model role in social welfare, corporate governance, and environmental preservation. Consequently, this research anticipates that property rights may moderate the relationship between digital transformation and ESG level.

This article separates the samples into state-owned and private enterprises based on the ownership type of the enterprises. The value is 1 if the samples are state-owned businesses; 0 otherwise. Column (1) of Table 6 displays the moderating influence of property rights test findings. Dgt regression coefficient is still positive and significant at the level of 1%, and the main effect still exists. The coefficient of the cross-product term between the nature of property rights and the degree of digital transformation is 0.0616, which is significant at the level of 1%, indicating that the nature of property rights can positively regulate the promotion effect of digital transformation on ESG level. Additionally, it supports the idea that state-owned businesses actively engage in greater social responsibility and more successfully carry out national objectives and strategies like digital transformation and green development.

4.4.2. Management Attributes

Prior to digital transformation, enterprises run by green-minded managers typically outperform others in terms of ESG performance. When making decisions, they typically take sustainability, the environment, and other considerations into account. As a result, they give long-term business development more thought than simply short-term profit. The influence of such values may enhance the overall ESG performance of enterprises. Thus, this study makes the case that enterprise management characteristics might possibly act as a moderator in the relationship between digital transformation and ESG level.

Referring to the method of Li et al. [39], this paper uses the text analysis method to construct a vocabulary base of green cognition of enterprise management, which involves keywords from three dimensions: green competitive advantage cognition, corporate social responsibility cognition and external environmental pressure perception. The specific test results are shown in Column (2) of Table 6. Dgt regression coefficient is still significantly positive at the level of 1%, and the main effect still exists. The coefficient of the cross-product term between management attributes and the degree of digital transformation is 0.000154, which is significantly positive at the level of 1%, indicating that management attributes can positively regulate the promotion effect of digital transformation on ESG performance, which also means that the stronger the management's green awareness, the more relevant experience and learning the organization is likely to have, and the more likely it is to contribute to ESG performance in digital transformation. However, enterprises that lack green management concepts may have relatively poor ESG performance before digital transformation. As digital transformation brings cost reduction, efficiency increase and technological progress to enterprises, these managers with green cognition may have more sufficient resources and energy to support the sustainable development of enterprises and further improve the ESG performance of these enterprises.

Table 6. Test of moderating effect6

Variables	(1) ESG	(2) ESG
Dgt	0.101 * * *	0.0540 * * *
	(0.0139)	(0.0120)
Digital_Property	0.0616 * * *	
	(0.0123)	
Digital_ManagerAttribute		0.00154 * * *
		(0.000568)
Controls	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
Observations	18660	18660
R-squared	0.504	0.520

4.5. Mediating Mechanism Test

Table 7. Test of mediating mechanism7 reports the results of mediating mechanism test. Columns (1) - (3) show the regression results of enterprise digital transformation on ESG level, enterprise digital transformation on green innovation capability, and green innovation capability after adding the mediating variable. The regression coefficients of columns (2) and (3) are significantly positive at the level of 1%, which indicates that enterprise digital transformation can improve ESG level by enhancing green innovation capability. When the intermediary variable GI is added, the Dgt

coefficient is reduced to 0.0499, which confirms that the green innovation capability plays a partial mediating role. Columns (4) - (6) show the regression results of enterprise digital transformation on ESG level, enterprise digital transformation on information disclosure quality, and information disclosure quality after adding the mediating variable, respectively. Similarly, the results of Column 5 show that enterprise digital transformation can improve ESG level by enhancing the quality of information disclosure, and the results of Column (6) confirm that the quality of information disclosure also has a partial mediating effect.

Table 7. Test of mediating mechanism7

Variables	(1) ESG	(2) GI	(3) ESG	(4) ESG	(5) Disclosure	(6) ESG
Dgt	0.0539 * * *	0.0354 * * *	0.0499 * * *	0.0595 * * *	0.0268 * * *	0.0503 * * *
	(0.0121)	(0.0112)	(0.0119)	(0.0137)	(0.00748)	(0.0133)
GI			0.113 * * *			
			(0.0159)			
Disclosure						0.345 * * *
						(0.0207)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Observations	18660	18660	18660	14602	14602	14602
R-squared	0.205	0.253	0.212	0.210	0.191	0.241

4.6. Endogeneity Test

There is a potential bidirectional causal relationship between enterprises' digital transformation and their environmental, social and governance (ESG) activities: on the one hand, digital transformation may promote enterprises to implement ESG-related decisions; on the other hand, in order to improve ESG performance, enterprises may also actively develop digital technologies and implement digital transformation strategies. In order to solve this endogeneity problem, this paper adopts the instrumental variable method. According to the method of Ma and Wu [40], this study selects the average level of digital transformation (Digital_IV) in the same city and industry as the instrumental variable. This choice is based on the following logic: the digital transformation degree of an enterprise is closely correlated with the digital level of other enterprises in the industry in the region where it is located, which meets the requirements of correlation; at the same time, there is no direct connection between the average level of digital transformation in the industry and the decision of any particular enterprise to carry out ESG activities, which meets the exogeneity condition. Its validity as an instrumental variable is further guaranteed by the fact that it is basically independent of other control factors and random disturbances. Table 8 displays the outcomes of the 2SLS regression using this instrumental variable. In the first stage of the test, the industry mean value of the digital transformation in the city where the enterprise is located (Digital_IV) has a significant positive impact on the degree of enterprise digital transformation at the level of 1%, which proves that the industry mean value of the digital transformation in the city where the enterprise is located has a strong correlation with the degree of enterprise digital transformation. In the second stage test, digital transformation still has a significant positive impact on the ESG level of enterprises. The Kleibergen-Paap rk LM statistic is 3770.7, which is significant at the level of 1%, rejecting the original hypothesis of no endogeneity of explanatory variables. The Kleibergen-Paap rk Wald F statistic is 34382.8, which is much higher than the critical value of 16.38 of Stock Yogo at the level of 10%, rejecting the original hypothesis that the instrumental variable is uncorrelated with the endogenous variable. The

regression results show that the positive promotion effect of enterprise digital transformation on ESG level still exists even considering the endogeneity problem.

Table 8. Endogeneity test8

Variables	(1) Dgt first_stage	(2) ESG two_stage
Digital_IV	0.916 * * *	
	(0.00522)	
Dgt		0.0366 * * *
		(0.00893)
Controls	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
Kleibergen-Paap rk LM		3770.7
Kleibergen-Paap Wald rk F		34382.8
Observations	18660	18660
R-squared	0.806	0.124

5. Conclusion and Implications

As the "dual carbon" goal is proposed and the concept of green development is deeply rooted in people's hearts, the ESG performance of enterprises not only affects their own sustainable development, but also is an inevitable requirement for China's green economic transformation and high-quality development. In light of the swift advancement of the digital economy, it is imperative to explore whether the digital transformation of enterprises can strengthen the performance of their ESG responsibilities for China to achieve green and high-quality economic development. Based on the unbalanced panel data of A-share listed companies in Shanghai and Shenzhen Stock exchanges from 2009 to 2020, this paper discusses the impact of digital transformation on ESG level and its mechanism. Through the robustness test, this study excludes the interference of other variables and ensures the reliability and stability of the conclusion to a certain extent. The final main conclusions are as follows: (1) The main effect test finds that the digital transformation of enterprises can promote the improvement of ESG level; (2) The mediating mechanism test finds that the digital transformation of enterprises can improve their ESG performance by enhancing their green innovation capability and information disclosure quality; (3) The moderating effect test shows that the ownership nature and management attributes of enterprises will have a moderating effect on the promotion effect of digital transformation on ESG performance.

As China vigorously avdocates the objective of "dual carbon" emission reduction, enterprises, as micro-entities of the market economy, should actively carry out ESG practices, which is vital for the sustainable development of the whole society. Based on the research findings, this paper puts forward the following countermeasures and suggestions: First, the government should further increase the investment in green digital technology research and development, and provide more financial and resource support for enterprises and research institutions. Innovation funds and R&D subsidies should be set up to encourage enterprises and research institutions to carry out technological innovation and accelerate the R&D and commercialization process of green digital technologies in enterprises. Second, the government need to further refine and optimize existing policies and incentives to ensure

that they more accurately match the actual needs of enterprises. As an illustration, enterprises should be encouraged to invest in green technology research and development and application through tax incentives and subsidies. At the same time, additional policy support and rewards are supposed to be provided to enterprises that effectively implement green transformation and digital upgrading. Third, enterprises need to clearly define their goals and directions for digital transformation, which should be closely aligned with their long-term strategies and sustainable development goals. And they also need to determine whether products, services, or business processes would most benefit from digitization and how these adjustments would assist the organization meet its ESG objectives. Fourth, the government and industry associations might collaborate to establish a shared platform for digitalization and green transformation within the industry. In addition to encouraging collaboration and knowledge sharing between enterprises and research institutions, this platform can act as a hub for technology exchange, experience sharing, and the dissemination of best practices. It can also accelerate the development and implementation of green digital technologies in enterprises. Fifth, a multifaceted monitoring and evaluation framework covering the government, business entities, NGOs and the public at large should be set up to monitor the dynamics of enterprises' practices in the green transition and digitalization process from all angles, and to ensure that their actions are deeply aligned with the sustainable development strategies set by the state.

References

[1] Hou N, Zhu Q, Zhao W, et al. Study on the impact of green management of paper enterprises on carbon performance in the background of carbon peaking and carbon neutrality[J]. Energy Reports, 2022, 8: 10991-11002.

[2] Chai K C, Huang Y, Chang K C, et al. Can Environmental Regulation Reduce Labor Costs and Improve Business Performance? Evidence From the Air Quality Index[J]. Frontiers in Public Health, 2020, 7.

[3] Liu J Q, Xu Y L. The Impact of ESG Investment on Corporate Resilience [J]. Journal of Audit & Economics, 2024, 39(1): 54-64.

[4] Liu Y, Pan H Y, Li Y J, et al. ESG Performance, Technological Innovation and Value Creation in Manufacturing Firms [J]. Scientific Decision Making, 2023(9): 23-36.

[5] Yi W Y, Yang Q, Zhang L L. Influence of ESG Performance on Corporate Value: An Empirical Analysis of ChineseA - Share Listed Sports Concept Companies [J]. Journal of Wuhan Sports University, 2023, 57(10): 47-54.

[6] Chen J, Huang S, Liu Y H. Operations Management in the Digitization Era： From Empowering to Enabling [J]. Journal of Management World, 2020, 36(2): 117-128+222.

[7] Ma D F, Li L W, Wang M K. Governance Effects of Digital Transformation: From the Perspective of Corporate Information Disclosure Violations [J]. Research on Financial and Economic Issues, 2023(11): 86-100.

[8] Zhang W, Xu N, Li C, et al. Impact of digital input on enterprise green productivity: Micro evidence from the Chinese manufacturing industry[J]. Journal of Cleaner Production, 2023, 414: 137272.

[9] Zhai H Y, Liu Y S. Can Digital Transformation Improve Corporate Bargaining Power? Based on the Perspective of Information Search and Customer Conversion Costs [J]. Journal of Zhongnan University of Economics and Law, 2023(6): 29-41.

[10] Zhao C Y, Wang W C, Li X S. How Does Digital Transformation Affect the Total Factor Productivity of Enterprises? [J]. Finance & Trade Economics, 2021, 42(7): 114-129.

[11] Mikalef P, Pateli A. Information technology-enabled dynamic capabilities and their indirect effect on competitive performance: Findings from PLS-SEM and fsQCA[J]. Journal of Business Research, 2017, 70: 1-16.

[12] Wahyuningrum I F S, Humaira N G, Budihardjo M A, et al. Environmental sustainability disclosure in Asian countries: Bibliometric and content analysis[J]. Journal of Cleaner Production, 2023, 411: 137195.

[13] Gao J Y, Chu D X, Lian Y H, et al. Can ESG performance improve corporate investment efficiency? [J]. Securities Market Herald, 2021(11): 24-34+72.

[14] Bai F P, Shang M T, Huang Y J, et al. Directors' and Officers' Liability Insurance and Corporate ESG Performance: Enabler or Resistance? [J]. South China Finance: 1-14.

[15] Yi B W. ESG information disclosure standardization construction from the perspective of data collaboration [J]. Finance and Accounting Monthly, 2022(17): 135-142.

[16] Liu S C, Yan J C, Zhang S X, et al. Can Corporate Digital Transformation Promote Input-Output Efficiency? [J]. Journal of Management World, 2021, 37(5): 170-190+13.

[17] Huang H L. Enterprise digital transformation and global value chain status promotion: based on the perspective of resource allocation [J]. Journal of Commercial Economics, 2022(7): 122-125.

[18] Yu W. Integrated Model and Competitive Advantage of Enterprise Digital Transformation [J]. Journal of Technical Economics & Management, 2022(2): 63-68.

[19] Shao B, Kuang X, et al. Business Process Digitalization and Enterprise Value of Manufacturing Enterprises: Based on the Perspective of Dynamic Capabilities [J]. Journal of Technology Economics, 2023, 42(7): 109-125.

[20] Meng X, Dong W T. Digital Transformation of Enterprises and Improvement of Export Competitiveness -Evidence from Chinese Listed Companies [J]. Journal of International Trade, 2022(10): 73-89.

[21] Li R, Wang Y, Lu Z. Does the Internet Business Model Affect the Earnings Quality of Listed Firms? ——— Evidence from China's Stock Market [J]. Accounting Research, 2020(10): 66-81.

[22] Zhao Q, Li H. Does ESG Rating Promote Corporate Green Technology Innovation: Micro Evidence From Chinese Listed Companies [J]. South China Journal of Economics, 2024(2): 116-135.

[23] Liu Z, Tong L, Zhong H. Digital transformation and green technology innovation: evidence from manufacturing listed companies [J]. Social Sciences in Guangdong, 2024(1): 37-47.

[24] Wu J, Xia Q, Li Z. Green innovation and enterprise green total factor productivity at a micro level: A perspective of technical distance[J]. Journal of Cleaner Production, 2022, 344: 131070.

[25] Wang F M, He J, Chen L L. Will Interlocking Directors with Green Experience Promote Quantity Increase and Quality Improvement of Enterprise Green Innovation [J]. China Industrial Economics, 2023(10): 155-173.

[26] Yang Z, Su D, Xu S, et al. Institutional investors and corporate green innovation: Evidence from China[J]. Pacific Economic Review, n/a(n/a).

[27] Yang W E, Lai P W, Han Z Q, etc. Do government policies drive institutional preferences on green investment? Evidence from China[J]. Environmental Science and Pollution Research International, 2023, 30(3): 8297-8316.

[28] Wan Q Q, Sun G G. Can Digital Transformation Improve the Quality of Corporate Information Disclosure? Based on Management Earnings Forecast [J]. Operations Research and Management Science, 2023, 32(11): 206-211.

[29] Chang M, D'Anna G, Watson I, et al. Does Disclosure Quality via Investor Relations Affect Information Asymmetry?[J]. Australian Journal of Management, 2008, 33(2): 375-390.

[30] Alsayegh M F, Abdul Rahman R, Homayoun S. Corporate Economic, Environmental, and Social Sustainability Performance Transformation through ESG Disclosure[J]. Sustainability, 2020, 12(9): 3910.

[31] Carnini Pulino S, Ciaburri M, Magnanelli B S, et al. Does ESG Disclosure Influence Firm Performance?[J]. Sustainability, 2022, 14(13): 7595.

[32] Fang X M, Hu D. Corporate ESG Performance and Innovation: Empirical Evidence from A-share Listed Companies [J]. Economic Research Journal, 2023, 58(2): 91-106.

[33] Wu F, Hu H Z, Lin H Y, et al. Enterprise Digital Transformation and Capital Market Performance: Empirical Evidence from Stock Liquidity [J]. Journal of Management World, 2021, 37(7): 130-144+10.

[34] Liu H M, Long J C, Shen Z H. Research on the Impact of Digital Transformation on the Green Innovation of Enterprises[J]. Science Research Management, 2023, 44(10): 22-34.

[35] Yi Z H, Jiang F X, Qin Y H. The Market Competition in Products, the Corporate Governance and the Quality of Information Disclosure[J]. Journal of Management World, 2010(1): 133-141+161+188.

[36] Tian Z, Zhu B, Lu Y. The governance of non-state shareholders and corporate ESG: Empirical evidence from China[J]. Finance Research Letters, 2023, 56: 104162.

[37] Lin X, Du G Z, Lin S X. Can Digital Transformation Improve Corporate Social Responsibility Performance? Analysis from the Perspectives of Resource Acquisition and Corporate Governance [J]. Financial Economics Research, 2023, 38(6): 114-127.

[38] Yuan C, Xiao T S, Geng C X, et al. Digital Transformation and Division of Labor between Enterprises: Vertical Specialization or Vertical Integration [J]. Journal of Management World, 2021(9): 137-155.

[39] Li Y B, Xia Y, Zhao Z. The Relationship between Executives' Green Perception and Firm Performance in Heavy-pollution Industries: A Moderated Mediating Effect Model [J]. Science & Technology Progress and Policy, 2023, 40(7): 113-123.

[40] Ma W B, Wu Y M. Does Digital Transformation Reshape the Geography of Companies: Research on Trans-regional Investment of Listed Companies? [J]. Economic Review, 2023(6): 87-105.